Final Report

San Francisco Bay Estuary Acclimation of Central Valley Hatchery Raised Chinook Salmon Project

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Final Report Salmon Acclimation Project

Introduction

In the Spring of 2008, the Fishery Foundation of California (FFC) received a grant from the State of California, the Resources Agency, Department of Fish Game pursuant to Fish and Game Code Section §1501.5(b), to acclimate Central Valley hatchery raised Chinook salmon upon transport by hatchery truck to San Francisco Bay. The Bay Delta Sport Fishing Enhancement Stamp provided the grant funds. The purpose of acclimation is to reduce the transport stress of the young salmon before release into the Bay where they are subject to salinity and temperature shock and intense predation by birds, predatory fish, and marine mammals.

In 2006 no acclimation was attempted due to lack of a contract and in all but one of the twelve years prior to 2007 acclimation was achieved by releasing salmon smolts from hatchery trucks directly into net pens at a receiving site in the Bay. In 2003, salmon were acclimated in an experimental tank mounted on a barge. The barge system was tested as a means of cutting costs and further improving survival of trucked salmon. Tank acclimation, it was thought, might reduce stress and mortality of trucked salmon over pens by acclimating the salmon released from the trucks to Bay water conditions over a short period of time, as opposed to directly releasing the salmon into the Bay from the trucks or into pens. The experiment was successful but proved logistically difficult and so was abandoned in the following years. Prior to 1995, hatchery trucks released fish directly into the Bay or Delta locations. In 2007, the foundation contracted with DFG to acclimate salmon using the net pen system and the results were excellent with approximately 10 million fish successfully received, acclimated and released into the Carquinez Strait from the net pens.

Trucking and net pen acclimation is generally considered a major factor in dramatically increased escapement of hatchery fish to Central Valley Rivers. Trucking has proven effective at increasing survival by reducing losses between the hatcheries and the Bay to poor water quality, water diversions, and predation. Previous tagging studies by DFG indicated that survival is also enhanced up to several fold by net-pen acclimation of trucked salmon smolts. Trucking and pen acclimation offer tremendous survival advantage over releasing young salmon at the hatcheries. The hatchery system is a controlled environment that allows a salmon to develop from an egg to a smolt in a safe, predation free background. Unlike in a river, hatchery pools afford fish with ample food and almost no predation pressure. In the hatchery there is no need for the young salmon to hide from predators and they develop without "learning" about the perils that are present in a natural aquatic environment. When these unsuspecting fish are released into a hostile environment such as a river or estuary they are easy prey for predatory birds and fish.

1 Multiple paired lots of code-wire-tagged salmon smolts were released: one lot of a pair was released directly into the Bay from a truck and a second from a truck into net pens for several hours acclimation before mid channel release. Tag returns in the ocean fishery were up to three time higher for pen acclimated salmon. (DFG unpublished data)

Despite the obvious survival advantage of trucking and pen acclimation there remain opportunities to further improve survival of hatchery salmon. One of these is barge acclimation. The potential advantage of barge over pen acclimation is a reduction in temperature or osmotic shock from direct release from trucks into pens. While direct transfer of Chinook salmon smolts from freshwater to saltwater generally is considered safe, there have been studies that show that direct transfer leads to shock and increased vulnerability to predators (Robertson and Bradley 1991; Smith et al. 1999a and 199b; and Carranza et al. 1994). Salmon migrating naturally downstream gradually move from freshwater to saltwater. The degree of osmotic shock is considered most severe in when juvenile salmon are transferred from freshwater to seawater directly, without the moderating influence of gradual transition to full salinity seawater afforded in nature. The scientific literature indicates that direct transfer increases salt levels in blood and tissues of young salmon and can disrupt biochemical processes and lead to stunted growth or even death. Although most species of salmonids undergo a physiological transformation that prepares them for the transition from freshwater to life in the dehydrating marine environment, a gradual rise in plasma ion concentration occurs as they experience an osmotic shock over several days. Young salmon gradually develop the ability to relieve their blood and tissue of salt by excreting salt via their kidneys and taking on more water through their gills and by drinking. The literature indicates that mortality from osmotic shock from direct transfer is on the order of 10 to 20 percent depending on circumstances. Some research indicates that the multiple stresses of transferring fish from hatcheries to salt-water exacerbates the stresses and leads to higher mortalities. In a conventional salmon farm, it's not unusual for up to 10 percent of the fish to die from osmotic shock, the trauma of being transferred from fresh to saltwater. Another 5 to 10 percent will become stunted. It also takes time for the survivors to adapt to their new surroundings and start growing again. And osmotic shock can stress fish and put them at risk for disease and predation. Like salinity shock, thermal shock is another possible effect of direct transfer of salmon from trucks to the Bay, pens, or tanks. Thermal shock would occur if the receiving water is too warm – stress occurs as water temperature exceeds 65F and mortality occurs at about 77F. Mortality can occur at sub lethal temperatures if the change in temperature exceeds 20F. Generally temperature is not considered a factor in trucking; however, some trucking of hatchery salmon is conducted as late as July. During the present 2008 study water temperature of the receiving water ranged from 56-70F, with no significant temperature difference between the two release sites. Average temperatures in April and May were 58F and 62F respectively, well within the preferred range and did not reach 65F at any time. The average temperature in June however was 66F with a minimum of 62F and two day high of 70F which is a very stressful temperature for young salmon. Temperature in the trucks was generally about 60F but warmed considerably during June as the hatchery waters warmed and less ice was used in trucks for transport to minimize thermal shock. The purpose of this report is to describe the results of the 2008 net pen acclimation program. Our objectives do not include an assessment of the merits of trucking or its effect on salmon populations, wild stocks, or straying.

Background

Hatchery Chinook salmon production in California in recent years has been approximately 48 million smolts and approximately 10-12 million of these were historically transported by truck and released in upper San Francisco Bay (San Pablo Bay). This year in response to the drastic decline of fall run Chinook salmon in the Central Valley system CDFG doubled the number of acclimation fish to 20 million. Three California State hatcheries located in the Central Valley (Feather, Mokelumne, and Nimbus hatcheries) account for roughly 99% of these off-site releases in the Bay. The young salmon are transported to the Bay to reduce or eliminate the mortality associated with moving from the rivers through the Delta. Transported fish may contribute to ocean fisheries at rates of three fold and higher compared to fish released upstream or at the hatchery. Unpublished data from the DFG's CWT database show substantial increases in both ocean contribution rate (1153%) and hatchery recoveries (259%) for Feather River Hatchery smolts released in the western Delta. Average ocean fishery contribution rates by release location were 0.310% for Battle Creek, 0.369 for RBDD, 0.318 for Princeton, and 0.947 for Benicia in the upper Bay (USFWS, unpublished data). These differences in ocean contribution rates were observed during years of drought and below average flows in the Sacramento River and were prior to pen acclimation that began in the mid 1990's. There has been no subsequent information on contribution rates, except as mentioned earlier; more recent studies of pen acclimation by DFG indicate that acclimation increases contribution up to threefold. Overall the increase in ocean contribution from trucking and pen acclimation may be as high as tenfold. Increases in adult escapement to rivers are believed to be less because of extensive straying of off-site released (trucked) fish. Straying of these fish has been estimated to be as high as 70%. The Chinook salmon smolts that are released off-site in the Bay come only from State hatcheries at Nimbus, Feather River, and Mokelumne hatcheries. These fish are for mitigation or enhancement from losses from dams and water diversions. The California Department of Water Resources provides funds for the Feather River Hatchery for mitigation of the State Water Project. The Salmon Stamp Program provides funding for enhancement fish for the Mokelumne and Feather River hatcheries. The Bureau of Reclamation provides funds for Nimbus hatchery fish. The East Bay Municipal Utility District provides funding for Mokelumne hatchery fish. The Four-Pumps Program of the State Water Contractors provides funding for Feather River hatchery fish through the Delta Fish Protection Agreement.

2008 Acclimation Program

The 2008 acclimation plan called for receiving up to 20 million salmon smolts into mobile net pens at two locations; the standard receiving site at the Wickland Oil Refinery dock on the southeast shoreline of San Pablo Bay and a new site in Mare Island Strait on the west bank directly opposite the Vallejo Municipal launch ramp. (Figure 1.) The standard release site was determined to be unsuitable for releases on outgoing tides due to the presence of a construction barge placed at the pier by contractors with Conoco Phillips; therefore a second release site was secured at Mare Island. The salmon were to be delivered by trucks from the three state salmon hatcheries from early April to late June. The Bodega Bay Fisherman's Marketing Association purchased an aluminum kelp

barge for modification into net pens for this year's project. The FFC designed the new pens and retrofitted them for immediate use. Net pen reconstruction began in mid-March and repairs and modifications were completed on March 28th. The net pens were launched and assembled in the water at the Vallejo municipal launch ramp on March 31st and then towed to Vallejo Marina where they were berthed for the remainder of the project. The FFC received salmon from April 4th through June 17th. In total, the FFC received 175 truckloads in 48 acclimation days. FFC crews took all truckloads and did not miss a delivery for any reason. Fish were delivered from Feather, Nimbus, and Mokelumne River Hatcheries. Under a separate agreement with USFWS an experimental group of federal fish from Coleman Hatchery was delivered between May 19th and June 5th. ² The federal fish were incorporated into spaces within the overall schedule and did not affect deliveries of state hatchery fish in any way. Overall daily truck loads ranged from two to six and averaged 3-4 truckloads per day. Total number of fish acclimated was 20,009,317. The Feather River Hatchery delivered a total of 9,873,163 fish, Nimbus hatchery 4,652,250 fish and Mokelumne River Hatchery delivered 4,216,974 fish. Coleman Fish Hatchery delivered 18 truckloads of federal fish for a total of 1,356,930 fish. Salinities measured in June ranged from 15-19% and were recorded for 5 days at Mare Island and 2 days at Conoco Phillips during June 9-17. (Table 1.) GPS coordinates at the point of release were recorded with a handheld Garmin 76 or a Lowrance GPS unit mounted on the tow boat, on May 29 and June 2, 3,4,9,12,13 and 17. (Table 2.)

No specific predation studies were done during release of acclimated fish, however the following general observations were made. Alternating release sites appeared to reduce overall presence of predators. Release sites were determined by tidal conditions creating a pattern of release site alternation every 3-5 days. FFC crews generally observed the lowest number of predators (birds, bass, and sea lions) on days one and two with a noticeable increase on days 3-5. In general predation was lowest in April when birds consisted mainly of gulls, no sea lions were observed (direct observation) and Striped Bass were be present in low numbers according to local fisherman. Caspian terns began showing up in May and Pelicans arrived in June, both increasing predation after release due to their ability to capture fish below the water surface. Tern predation appeared to be somewhat limited to the Wickland (Conoco Phillips) release site as very few terns were observed in the Mare Island Strait over the course of the project. Striped bass predation appeared to be down from last year as evidenced by the fewer numbers of fisherman and party boats in the area. On May 22nd a 6 pound Striped bass was caught by hook and line in the Mare Island Strait and found to have 21 partially digested salmon smolts in its stomach along with several krill.

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[&]quot;Due to the recent collapse of salmon abundance, Coleman National Fish Hatchery (Coleman NFH) conducted an experimental trucked release of 1.4 million fall Chinook salmon smolts to San Pablo Bay. The experiment is designed assess the effects of releases of fish west of the delta on contributions to the ocean fishery (commercial and sport), contributions to the Sacramento River sport fishery, returns to Battle Creek and the Coleman NFH, and rates of straying. The 1.4 million juveniles that were trucked consist of the three groups that were selected from three different segments of the spawning timing. Coded-wire tags and adipose fin clips have been applied to fish in these groups at a constant rate of 25%. An additional 11.2 million juveniles (which were also marked at a rate of 25%), were released directly at the hatchery. Evaluation of these releases will occur through data collection from ocean and inriver harvested fish and adults returning to Coleman NFH during the years 2009 to 2011." Scott Hamelberg Project Leader Coleman National Fish Hatchery Complex 24411 Coleman Fish Hatchery Road Anderson, CA 96007

Mortality in the net pens was not a significant factor. Most fish when given time to acclimate recovered from disorientation caused by transport along with temperature and osmotic shock. The fish from Nimbus and Mokelumne hatcheries appeared to transition more quickly than the Feather River fish. Possible reasons are a shorter trip and, according to the truck drivers, Nimbus, Mokelumne and Coleman increased salinity of transport water to reduce osmotic shock whereas Feather did not. FFC crews observed a slight difference in condition between fish released at Conoco Phillips where a permanent rigid 150 foot pipe is mounted at the pier and Mare Island where a flexible tube is used to release fish. The flex tube is shorter and smaller in diameter which created more turbulence and stress during the release. Fish released via the larger longer rigid tube at Wickland Pier (Conoco Phillips) acclimated faster and appeared less stressed than those released with the flex tube. In one special case mortality was significant however it was due to a pre-existing condition. On May 19th Coleman Hatchery notified us that one truckload of fish had an oxygen problem en route and 75% mortality was observed upon arrival. The remaining 25,000 fish (approx.) in the load did survive the trip however and were acclimated and released along with the dead fish in the load. This event may explain the high number of smolts found in the gut of the previously mentioned striper caught on May 22^{nd.} All other Coleman fish looked very healthy upon arrival and acclimated extremely well.

During the project we considered methods to increase survival and decided to experiment with feeding the smolts during acclimation prior to release. Our hypotheses were that since the fish are not fed for 2 days prior to trucking they may be more likely to come to the surface looking for food making them vulnerable to bird predation after release. And the smolts may be more likely to swim deeper and begin to forage on their own if they have sufficient energy. Fish responded best to feeding after at least one hour of acclimation but no other patterns were evident beyond that observation. It is not known if the feeding enhances survival, however there were no observed negative impacts. Fish food was donated by Coleman and Mokelumne Hatcheries.

The overall success of this year's acclimation project was a direct result of excellent communication and continual coordination between hatchery managers, truck drivers, administrative staff and the contractor (FFC). All entities exercised flexibility, creativity and a professional attitude which was reflected throughout the project and resulted in a record acclimation year with excellent results.

Literature Cited

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Table 1. Salinity readings in June 2008

Date	Salinity %	Location
6/9	18.5	Mare Island
6/10	19.0	Mare Island
6/11	16.0	Mare Island
6/12	16.5	Mare Island
6/13	18.5	Mare Island
6/16	15.5	Conoco Phillips
6/17	15.0	Conoco Phillips

Table 2. GPS Coordinates for some releases in May and June

Date	Release Start		Release Finis	GPS unit	
5/29/2008	N:38.07835	W:122.2463			Garmin 76
5/29/2008	N:38.07024	W:122.24685			Garmin 76
5/29/2008	N:36.06914	W:122.24928			Garmin 76
6/2/2008	N:38*03.605	W:122*14.258	N:38*03.555	W:122*13.025	Lowrance
6/3/2008	N:38*03.560	W:122*13.812	N:38*03.732	W:122*12.439	Lowrance
6/4/2008	N:38*03.825	W:122*14.041			Lowrance
6/9/2008	N:38*05.284	W:122*15.338	N:38*04.173	W:122 14.796	Lowrance
6/12/2008	N38*05.685	W:122*14.970	N:38*05.266	W:122*15.746	Lowrance
6/13/2008	N:38*05.124	W:122*15.182	N:38*05.900	W:122*15.015	Lowrance
6/17/08	N:38*03.573	W:122*14.545	N:38*03.582	W:122*14.338	Lowrance

Project Area and Receiving Sites 2008



Figure 1. 2008 Receiving sites